Out-of-Tank Evaporator System Skid

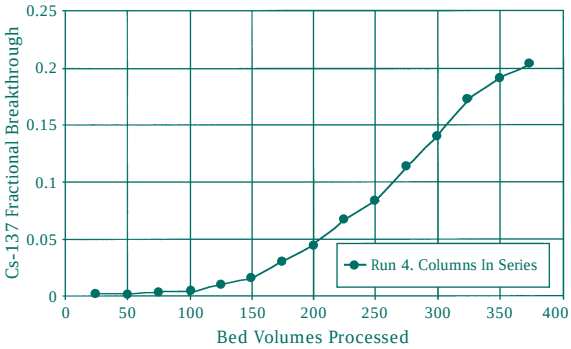
OTE Modular Evaporator Performance Summary, FY 1998

Campaign #	Feed Volume (gal)	Distillate Volume (gal)	Volume Reduction (%)	Decontamination Factor*
1	23800	9660	41	2.80E+06
2	16150	7909	49	1.60E+06
3	22400	13317	59	9.40E+05
4	20272	10880	54	1.00E+04
Total	82622	41766	Avg. 51	

*Decontamination Factor is a ratio of feed to distillate contaminant concentrations, providing an indication of the purity of the distillate. Values at or above 1.00E+04 are preferred.

Note: Each processing campaign required about 3 weeks to complete.

➢ The CRS removed over 1000 curies of cesium during processing of 30,000 gallons of supernate. A typical breakthrough curve for Cs^{137} (i.e., the concentration of Cs^{137} in the effluent divided by the concentration in the inlet) during processing is shown in the figure at the left. Essentially all of the cesium is removed while processing the first 100 column volumes (approximately 1000 gallons) of supernate; then, the concentration of cesium in the effluent increases as the IE-911 ion exchange material becomes fully loaded with cesium.



Loading Curve showing concentration of cesium (as a fraction of initial concentration) exiting the Cesium Removal System.

Operation/Design

The OTE, CRS, and SLS systems have automated systems for ensuring optimum operating conditions at all times. The systems are modular, allowing easy installation and removal for transport between sites. Modular shield walls composed of concrete, lead-filled steel, or solid steel provide shielding of vessels and piping during waste processing.

Subsequent Deployment

➢ With technical support from ORNL, a modular evaporator will be deployed at the Savannah River Site (SRS) Consolidated Incineration Facility (CIF) in South Carolina. The CIF evaporator is expected to be operational in the summer of 2000.

➢ A CRS system is currently being designed as a salt disposition alternative process for treatment of HLW at SRS. CRS and SLS are also being considered for deployment at the Idaho Nuclear Technology Engineering Center (INTEC).

Commercial Availability

All of the above modular systems are commercially available from design and manufacturing firms.

➢ TTI Engineering (Walpole, MA) designed and fabricated the CRS, which uses UOP Molecular Sieves' (Mt. Laurel NJ) sorbent (Ionsiv IE-911).

➢ Delta Thermal Systems of Pensacola, FL designed and fabricated the OTE.

➢ NUMET Engineering, LTD, of Peterborough, Ontario designed and fabricated the SLS. The SLS cross-flow filter elements are available from Mott Corporation, Farmington, CT.

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T E C H N O L O G Y D E P L O Y M E N T

Out-of-Tank Modular Evaporator, Cesium Removal Ion Exchange, & Solid/Liquid Separation Systems for Waste Reduction in Tanks

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Office of Environmental Management
Office of Science and Technology
Tanks Focus Area

The Accelerated Site Technology Deployment (ASTD) Program funded 13 projects in 1998 and 32 in 1999. ASTD leverages funding with the DOE site cleanup managers to accelerate the deployment of available innovative technologies that can save money and time for environmental management operations. ASTD helps eliminate perceived business risks associated with new technologies by providing valuable cost and performance data to encourage multi-site deployment of these technologies, thus expanding cost-saving opportunities across the DOE complex. This project is one example of ASTD's success, where the project team has contributed to accelerating the closure of the Oak Ridge National Laboratory tank waste facilities.

Problem

The Department of Energy's (DOE) *Accelerating Cleanup Paths To Closure* document (DOE/EM-0362, 1998) identified over 355,000 cubic meters of high-level waste (HLW) sludges, salt, and liquid stored in underground storage tanks at DOE's Hanford, Idaho, and Savannah River sites that require treatment and disposal. In addition, large quantities of Remote Handled Transuranic (RH-TRU) tank waste exist at the Oak Ridge National Laboratory (ORNL). During tank waste retrieval, transfer, and cleanup operations, large quantities of liquid will be added to the waste.

- Methods are needed for separating suspended solids and reducing liquid volumes prior to final processing.
- If the radioactive cesium present in these wastes can be removed, much of the volume could be disposed of as "low-level" or Class C waste with the remaining smaller volume requiring disposal at the Waste Isolation Pilot Plant. Disposal costs could be significant lower under this scenario.

Solution

The Modular Solid/Liquid Separation (SLS) [TMS #550], Cesium-Removal Ion Exchange (CRS) [TMS #21], and Out-of-Tank Evaporator (OTE) [TMS #20] Systems are coupled to efficiently reduce the radioactivity and volume of tank wastes. These processes conserve tank storage capacity by evaporating excess water (OTE) and facilitate lower-cost disposal of the remaining liquids by reducing cesium content using a state-of-the-art, selective ion-exchange material known as crystalline silicotitanate (CRS). SLS cross-flow filtration technology removes suspended solids that would otherwise foul the OTE and CRS systems.

Status

- In FY1997 and 1998, OTE and the CRS were demonstrated and deployed at ORNL to successfully meet established goals.
- Under the ASTD program, the CRS was modified in 1998 to operate in series with the SLS and OTE systems and to improve packaging operations for the cesium-loaded ion-exchanger at the Oak Ridge Bethel Valley Watershed Project. In 1999, the CRS-OTE-SLS coupled system began operations. Since that time, 98,000 gallons of tank waste liquid were processed by the SLS; over 5,600 curies of cesium and 32,000 gallons of excess water have been removed.
- The CRS-OTE-SLS system is currently scheduled to complete six additional campaigns of about 20,000 gallons each during FY-1999 and 2000.

Optimum Application

These technologies should be considered for application at DOE sites where large volumes of highly radioactive liquids and sludges are being stored for future retrieval, processing, and disposal.

The Solid Liquid Separation System at ORNL, Melton Valley Storage Tank facility.

Technology Limitations

The waste must be well characterized and treatability testing should be conducted to determine the applicability of these technologies.

Baseline

These three technologies (OTE, CRS, and SLS) have been compared to the following baseline methods for tank waste treatment:

- direct solidification of liquids without evaporation of excess water, resulting in large volumes of grouted waste;
- no cesium removal requiring greater shielding and handling, thus significantly increasing costs for operation and transportation;
- gravity settling and decantation, which can be time consuming, space intensive, and not as effective in removal of small particles.

Cesium Removal System Shielded Ion Exchange Columns

Costs and Cost Savings

- Deployment of these three technologies as a coupled system or as separate components will reduce the overall cost of DOE tank waste treatment and disposal.
- According to the Accelerated Site Technology Deployment Plan for this project, deployment of these technologies at ORNL and SRS is estimated to cost $27.8M; however, cost savings are estimated at $84M through FY2006.

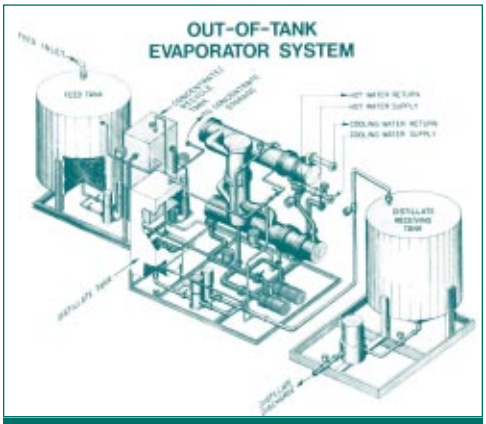
Technology Description

The OTE, CRS, and SLS are all designed as separate systems that can be coupled to meet waste volume reduction and treatment needs at certain sites. All systems are modular and skid-mounted for ease of installation and removal. The systems are custom designed to meet site requirements and for remote control. Modular radiation shielding is provided for system components that are expected to be sources of high radiation.

The OTE uses sub-atmospheric pressure technology to efficiently reduce liquid volume 40% or more. OTE is designed to produce up to 90 gal/hr of distillate. The OTE has modular shielding for radiation protection and the control system is designed for remote, automated operation.

The CRS is designed to remove cesium from high-salt liquid waste using an engineered form of crystalline silicotitanate sorbent made by UOP Molecular Sieves under the trade name Ionsiv IE-911. The granular IE-911, which is 300 times more efficient than standard ion-exchange resins, is loaded into flow-through columns to obtain efficient contact with the tank liquids. The cesium-rich IE-911 is later removed from the column and dewatered for disposal as solid waste.

The SLS, which prevents fouling of ion-exchange columns, reduces scale buildup on evaporator heat-transfer surfaces, and reduces sludge accumulation in storage tanks, is based on cross-flow filtration technology. Tubular filter elements are arranged in a bundle within a housing similar to a shell-and-tube heat exchanger. The filter elements are manufactured using a special metal-sintering process, which is controlled to produce a material with a particular pore size, typically less than 1 micrometer. The waste-containing suspended solids are circulated through the tubes at a high velocity to minimize the buildup of solids on the tube surface and to help maintain a high filtrate flow rate. Pressure is applied to the circulating fluid to force filtrate through the tube walls.



Schematic of the Out-of-Tank Evaporator System

Performance

- In FY98, OTE was utilized for four operating campaigns creating 40,000 gallons of additional Melton Valley Storage Tank capacity, representing an average of fifty-percent volume reduction, as shown in the table on the next page.